

Drill Embedded Nanosensors For Planetary Subsurface Exploration Project

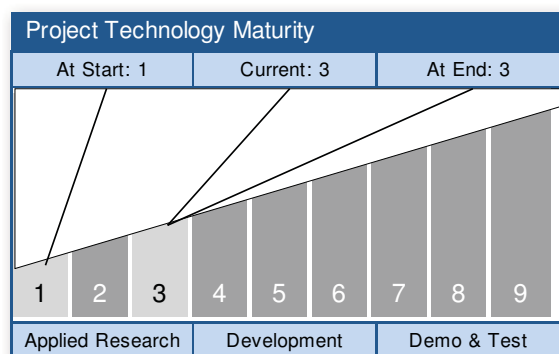
Center Innovation Fund: ARC CIF Program
Office Of The Chief Technologist (OCT)

National Aeronautics and
Space Administration



ABSTRACT

We have developed a carbon nanotube (CNT) sensor for water vapor detection under Martian Conditions and the miniaturized electronics can be embedded in the drill bit for collecting sensor data and transmitting it to a computer wirelessly. This capability will enable the real time measurement of ice during drilling. With this real time and in-situ measurement, subsurface ice detection can be easy, fast, precise and low cost.



Technology Area: Science Instruments, Observatories & Sensor Systems TA08 (Primary)

ANTICIPATED BENEFITS

To NASA funded missions:

This technology will benefit for STMD on the planetary exploration - water search on Mars and Moon.

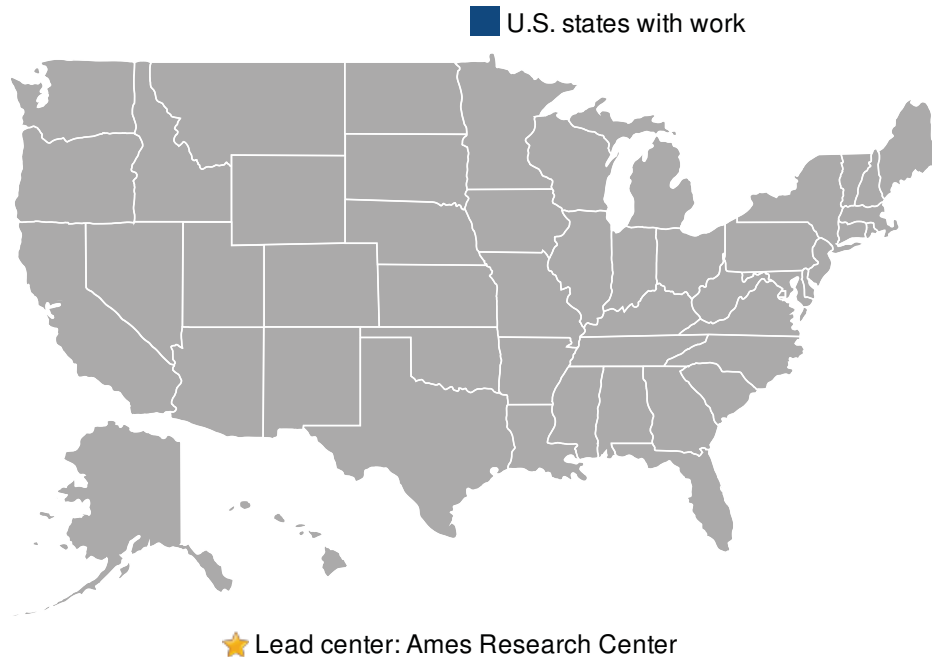
The technology can be expanded for other volatiles detection on different planets including earth, which will benefit for SMD's missions.

To other government agencies:

The nanosensor technology has been used by DHS for toxic gases and vapors detection

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Read more on the last page.



DETAILED DESCRIPTION

Current methods for sensing icy deposits on Mars or the moon include volume hydrogen measurements in a 1 m³ volume from a surface neutron spectrometer, optical spectral measurements to identify water spectral lines, or direct analysis of samples using mass spectroscopy. The latter two methods require samples to be on the surface or fed into an instrument. The detection limit of optical spectroscopy is ~1% water ice in a cuttings mixture. In contrast CNT sensor's detection limit is 10⁻⁶ – 10⁻⁹ and the sensors are tiny with significantly lower power usage compared to other instruments. The drill mounted CNT sensor can also detect ice as it is encountered by the drill bit at very low concentrations, obtaining fine scale information on the vertical structure of the icy material. Potentially, CNT sensors combined with drilling afford a new approach for detection and measurement of volatiles.

With CIF support in 2013, we started with CNT sensors that operate under Earth conditions optimized to sense organic volatiles and developed a CNT sensor capable of detecting water vapor, requiring special coatings applied to the CNT. We characterized the sensor performance under Mars pressure (~6mbar) and temperature (-45oC) conditions, showing that it could detect small quantities of water vapor introduced into ...

MANAGEMENT

Principal Investigator:

Jing Li

Co-Investigator:

Carol Stoker

DETAILED DESCRIPTION (CONT'D)

its vicinity. We compared our CNT sensor with commercially available RH sensors. The test results show that commercial sensors do not work under vacuum conditions. So, our CNT sensors exceed the performance of these commercial sensors for Martian conditions.

We miniaturized the sensor, and constructed data acquisition and wireless communication electronics to fit inside a drill string. The wireless communications allows us to transmit the CNT sensor signal from the borehole without bringing wires through the rotating interface. We then constructed a simulated borehole and drill string and tested sensor performance detecting small quantities of water vapor under Martian conditions. The wireless communication board can transmit the sensor data to a USB receiver plugged into a computer for data streaming.

The work remaining is to complete sensor installation into a drill string and test it drilling into icy material in a Mars environment, which requires a Mars chamber that requires use of unique Mars drill testing facilities at Honeybee Robotics.

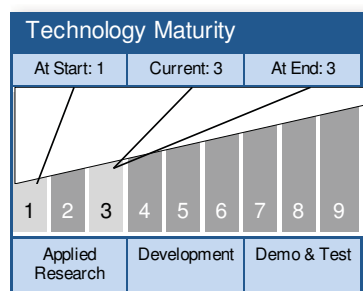
Possible applications of CNT sensors for water detection include prospecting for buried ice on the Moon, and characterizing feedstocks for ISRU on the moon or Mars. An ISRU demonstration proposal to the Mars 2020 rover has expressed interest. CNT borehole instruments that detect volatiles like methane should interest the fuels industry.

ADDITIONAL AND DETAILED TECHNOLOGY AREAS

- TA10: Nanotechnology

TECHNOLOGY DETAILS

Drill Embedded Nanosensors for Planetary Subsurface Exploration



TECHNOLOGY DESCRIPTION

A carbon nanotube (CNT) sensor, capable of detecting water vapor, requiring special coatings applied to the CNT, has been developed. This sensor can detect water vapor under Mars pressure (~6mbar) and temperature (-45oC) conditions. We miniaturized the sensor, data acquisition and communication electronics to fit inside a drill string for wirelessly transmitting sensor data and tested it in a simulated borehole and drill string.

This technology is categorized as a hardware subsystem for tools

- Technology Area
 - TA08 Science Instruments, Observatories & Sensor Systems (Primary)
 - TA10 Nanotechnology (Additional)

CAPABILITIES PROVIDED

The CNT sensor's detection limit is 10^{-6} – 10^{-9} and the sensors are tiny with significantly lower power usage compared to other instruments. The drill mounted CNT sensor can also detect ice as it is encountered by the drill bit at very low concentrations, obtaining fine scale information on the vertical structure of the icy material. Potentially, CNT sensors combined with drilling afford a new approach for in-situ and real time detection and measurement of volatiles.

Potential applications of CNT sensors for water detection include prospecting for buried ice on the Moon, and characterizing feedstocks for ISRU on the moon or Mars. An ISRU demonstration proposal to the Mars 2020 rover has expressed interest. CNT borehole instruments that detect volatiles like methane should interest the fuels industry.

Performance Metrics		
Metric	Unit	Quantity
sensitivity to water vapor under mars condition	ppm	250



ANTICIPATED BENEFITS

To other government agencies: (CONT'D)

in homeland security and DOD for warfare agent detection. It can also be used by EPA, USDA and NOA for chemical detection.

To the nation:

The nanosensor technology can be used in industry for process control; environmental monitoring, medical diagnosis and homeland security applications.